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A Study of the Embryology of *Mamestra configurata* (Walker) (Lepidoptera, Phalaenidae)

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Abstract

The embryonic development of the bertha armyworm is traced from the time of oviposition until blastokinesis. The following are described: the egg; fertilization and cleavage; formation of blastoderm, serosa, and amnion; the germ band; formation and differentiation of the lower layer; germ layers and derivatives; blastokinesis.

Introduction

The bertha armyworm is a native of the Canadian prairies and park belt region where, originally, it occurred feeding on a variety of native broad-leaved plants. When these areas became settled, it spread to cultivated plants such as sweet clover, alfalfa and flax. It has in time become an important agricultural pest and, during the last thirty years, it has been responsible for extensive damage in the western provinces of Canada. According to King (1929) the widespread outbreak of 1928 involved the greater part of the prairie area of Manitoba, Saskatchewan and Alberta, extending into British Columbia.

When, during the second world war, rape became an important crop in some areas of Saskatchewan, the armyworm adopted it as a host with consequent great losses in the areas concerned.

This armyworm is also an important pest of the garden where it attacks vegetables such as cabbage, beans, and peas, and also a variety of flowers.

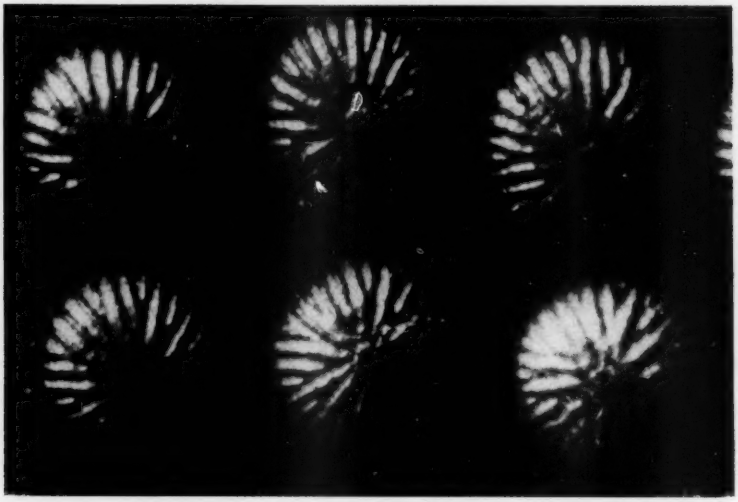
Although numerous studies of the embryology of the Lepidoptera have been made, our information on the development of the diverse members of this important order is still far from complete. The family Phalaenidae, especially, has so far received scant attention from the insect embryologist. The only extended account that has come to the attention of the writer is that by Gross and Howland (1940) on *Prodenia eridania*, and this deals only with the early developmental processes. For this reason a study of the embryology of the bertha armyworm would seem to be fully justified.

This species is a suitable subject for an embryological study. Adults are easily reared from overwintering pupae; they mate readily in captivity; each female lays a large mass of clean eggs in a regular pattern (fig. 1); oviposition on an artificial substrate is easily induced; the reticulation in the chorion and a ring of pigment appearing along the equatorial plane in the egg a few hours after oviposition (fig. 2) greatly facilitate orientation; after fixation the chorion can be removed without much difficulty as an aid in sectioning.

This paper deals with the broad developmental processes of *Mamestra configurata* from the time of oviposition until blastokinesis. A detailed account of the embryology of different organs and systems is to follow after further study.

Acknowledgments

The material that forms the subject of this study was obtained from the Dominion Entomological Laboratory at Saskatoon through the courtesy of Dr. H. McDonald. The writer takes pleasure to acknowledge his indebtedness to Dr. McDonald for making available his large collection of overwintering



Text Fig. 1. Newly-laid eggs of *Mamestra configurata*. Note reticulation of chorion and position of micropyle.

specimens and for calling his attention to the advantages of this species as a subject for embryological studies. Thanks are also due Mr. C. Devlin of the Dominion Entomological Laboratory for his help in rearing adults, to Miss Martha Pressesky of this University for laboratory assistance and to Mr. Norman Ferrier, Department technician, for help with the photography.

This project was carried on under a grant from the National Research Council.

Materials and Methods

Adult moths, soon after emergence, were introduced into a cylindrical wire cage, the lower end of which was closed by a removable cardboard cover. Three moths, one female and two males, were held in each cage. Narrow strips of filter paper afforded a resting place for the moths and were also commonly selected by the female for oviposition. The upper end of the cage was covered with a cotton plug moistened with sugar water to permit the moths to feed.

Since the moth is nocturnal, some difficulty was at first experienced in securing eggs that could be timed with reasonable accuracy. This difficulty was, however, overcome by keeping the moths in a lighted room at night and covering the cages with a heavy black cloth during the day to alter the period of mating and oviposition. A series of well-timed egg masses was thus secured.

Each female lays the eggs (some one hundred to one hundred and fifty) in a regular pattern, each egg with its micropyle directed away from the substrate (fig. 1). When an egg mass was secured on filter paper, the paper was divided by means of a razor blade into strips, each containing from six to eight eggs. These strips were kept at room temperature (68°-72°F.) in small shell vials. At regular intervals, varying from two to six hours, depending upon the age of the eggs, fixing solution was poured into a vial and the proteins coagulated by heat. When the solution was cool, each egg was pricked with a minuten nadel to permit better penetration of the fixing fluid. Bouin's was used almost exclusively as the fixing agent and gave satisfactory results.

Each egg is covered by a tough chorion which makes sectioning difficult. Hence the paraffin-celloidin method of imbedding was used in the beginning. However, it was observed that fixation caused slight shrinkage of the egg from the chorion making it possible to remove the latter without much difficulty. By exerting slight pressure on the egg while observing with a binocular microscope, the space between the egg and the chorion was increased. A slit was then made in the chorion with a fine sharp needle and the egg expelled. This was done before the egg was moved up the alcohol series.

Prior to embedding, a series of small paraffin blocks was prepared. These were fastened to glass slides. An infiltrated egg was then transferred with a warm pipette to a block and oriented with a flame-heated needle. When hardened, the block was trimmed, the shape indicating the plane at which the egg would be sectioned later.

Sections were cut at six micra and stained in Delafield's Haematoxylin and counterstained with eosion. Tertiary butyl alcohol was used as the dehydrating fluid.

The illustrations were prepared by projecting a section on a screen using the Bausch and Lomb triple purpose microprojector. An outline drawing was then made on ordinary paper and later transferred to bristol board. All drawings are somewhat diagrammatic.

The Egg

The egg measures .45 mm. in diameter. It is spherical in form with the lower surface somewhat flattened where it comes in contact with the substrate. The micropyle is in the centre of a small circular elevation at the upper pole. The chorion is colorless, with a series of longitudinal ridges and depressions radiating from the upper pole (text fig. 1). The sculpturing is most prominent in the upper hemisphere. The micropylar area has faint leaf-like impressions around the micropyle.

The eggs are laid in a mass of 100-150 eggs, in a neat pattern of diagonal rows. The mass is compact, with each egg just touching the neighboring eggs.

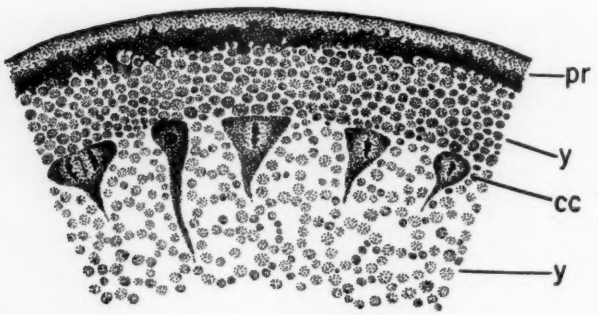
Prior to the formation of the blastoderm, the vitelline membrane adheres closely to the periplasm (also known as Keimhautblastem, cortical ooplasm, peripheral protoplasm, formative cytoplasm, etc.). With the appearance of cells it becomes separated from the underlying serosa and germ band.

The periplasm is divided into outer and inner layers. The former is finely granular and shows little affinity for stain. The inner layer is densely granular and stains readily with basic dyes. It is generally thin in the region immediately below the micropyle and along the broad equatorial band, but somewhat thicker at the poles, especially in the region of the polar plasm (figs. 4-7). From the inner surface of the periplasm fine irregular strands of cytoplasm penetrate the yolk. These strands, the protoplasmic reticulum, extend inward to communicate with the cytoplasm around the nucleus. The yolk in the form of globules of varying size makes up the greater part of the egg.

Some twenty minutes after oviposition, the female pronucleus has entered the polar plasm and is in the first maturation division (fig. 4). At the same time the sperm, surrounded by a small mass of cytoplasm, is located a short distance below the micropylar region. The change from the spermatozoon form to that of the pronucleus must be very rapid since in all such eggs examined the sperm had already assumed the latter form.

Fertilization and Cleavage

Fertilization is accomplished within the second half-hour following oviposition. At the end of the first hour three polar bodies are found in the polar



Text Fig. 2. Five-hour egg of *Mamestra configurata* with cleavage cells approaching the periplasm. Note nuclei of cleavage cells in mitotic division.

plasm and the female pronucleus has fused with the sperm (fig. 5). The synnucleus is located where formerly the sperm was found. This suggests that fertilization occurs after an inward migration of the female pronucleus, following the second maturation division.

In *Prodenia* Gross and Howland (1940) found that the polar bodies fuse into a single vesicle at the time of the second cleavage division. It has been impossible to determine whether the same condition exists in *Mamestra*. What appear to be two disintegrating bodies were observed in the polar plasm at the time when four cleavage nuclei were present. No trace of polar bodies was found in subsequent stages.

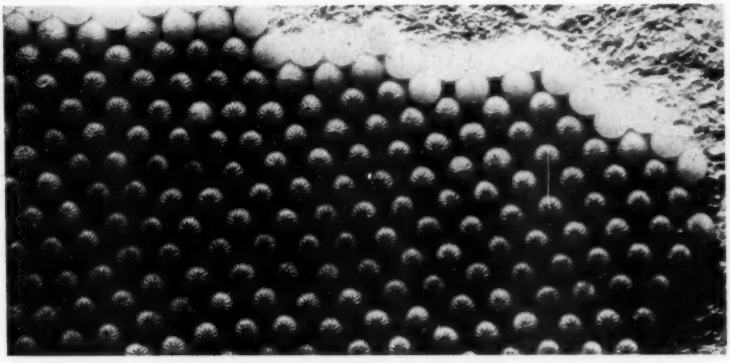
A series of synchronous divisions follows fertilization accompanied by a centrifugal migration of the resulting cells. The early cleavage nuclei are each surrounded by a small stellar mass of cytoplasm. As more and more cells appear and further progress in outward migration has been made, the cytoplasm of the cleavage cell becomes comet-shaped with the blunt end directed forward. The nucleus is located in the head of the comet. This is most clearly seen in sections cut along the median vertical plane (fig. 8) or in the equatorial horizontal plane. By the end of the fourth hour the cleavage cells have traversed half the distance from the centre of the egg to the periphery., Not all cleavage cells take part in this outward migration. Some lag behind and form the yolk cells or vitellophags. During outward migration, cleavage cells undergo mitotic division (text fig. 2). The cytoplasm contracts along the longitudinal axis and widens at the base. The cell is now subtriangular in shape. Since the number of cells in the process of division in some eggs is large, while in other eggs of the same age none of the cells are found dividing, it is evident that in cleavage the divisions are nearly synchronous.

When the outward migration of the cleavage cells takes place, a change occurs in the yolk. The part already traversed by the cells is clearer than the

PLATE I

Explanation of Figures

Fig. 1. Mass of newly-laid eggs of *Mamestra configurata* on filter paper.
Fig. 2. Mass of twenty-five-hour eggs on filter paper.
Fig. 3. Small mass of eggs laid on host plant. Courtesy Dominion Entomology Laboratory, Saskatoon.



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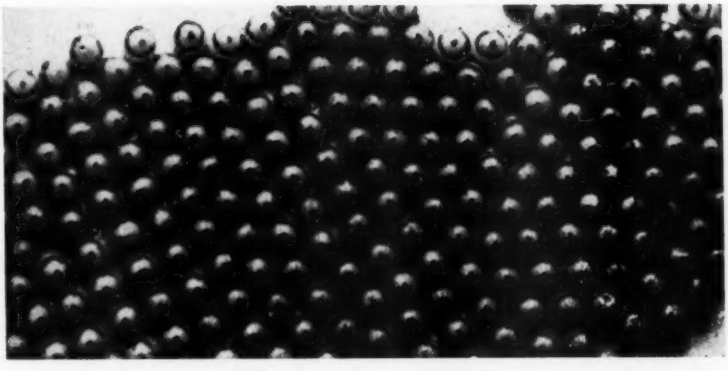

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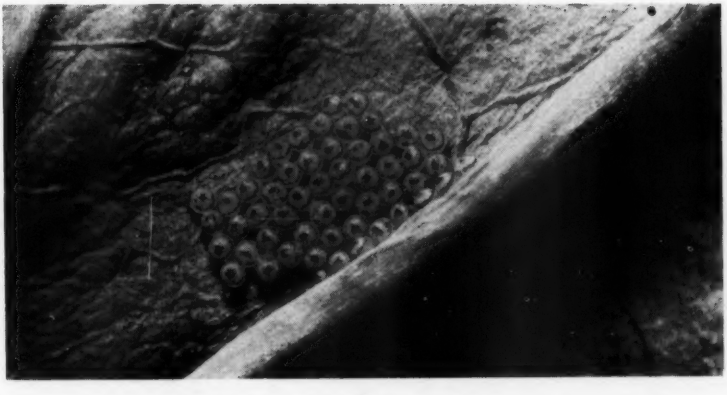

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PLATE I

part still to be traversed (text fig. 2 and fig. 8). A similar situation was found by Eastham (1927) in *Pieris* and by Gross and Howland (1940) in *Prodenia.* The latter authors account for this by assuming that the outward bound cells have a digestive action on the yolk. They are also inclined to agree with Eastham that the difference in the two zones of the yolk is due to a difference in the amount of cytoplasm, the inner zone being poorer in cytoplasm than the outer. The author, from a careful examination of his material, finds that there is an actual attenuation of yolk brought about by the migrating cleavage cells. This attenuation, he believes, is due not to a digestive action of the cells but to a mechanical displacement of the yolk globules by the outward-bound cleavage cells. Since the line of demarcation between the two zones coincides with the advancing fronts of the cleavage cells, such a postulate would not appear to be unreasonable.

Much speculation has centred around the underlying cause whereby the cleavage nuclei are made to migrate peripherally. The subject is fully discussed by Eastham (1927) who accounts for the outward migration of the cleavage nuclei by assuming a centrifugal streaming of the reticular cytoplasm which draws the nuclei peripherally through the yolk. The author, however, feels that an equally strong case could be made in favor of the assumption that the peripheral migration is the result of an independent outward movement of the cleavage cells. The shape of the individual cleavage cell and the position of the nucleus within the cell are in favor of this. Moreover, it is felt that nuclear material is more likely to be the "guiding influence" in this activity than cytoplasm.

Formation of Blastoderm, Serosa and Amnion

By the end of the sixth hour the outwardly-migrating cleavage cells approach the periplasm. They first enter the cortical cytoplasm in the polar regions.

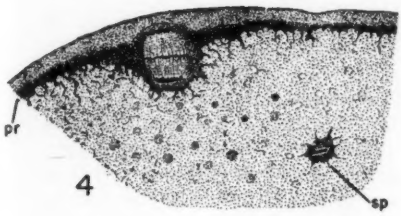
PLATE II

Explanation of Figures

Fig. 4. Egg with female pronucleus in first maturation division and sperm in micropylar region.
Fig. 5. Egg immediately after fertilization showing three polar bodies and synnucleus. Median vertical section.
Fig. 6. As in figure 5, enlarged.
Fig. 7. Egg after the second cleavage division. Vertical section.
Fig. 8. Four-hour old egg showing outwardly migrating cleavage cells and yolk cells. Median vertical section.
Fig. 9. Six-hour old egg. The cleavage cells have entered the periplasm. Median vertical section.

Abbreviations

am, amnion
am.f, amniotic fold
bl, blastoderm
br, brain
cc, cleavage cell
ch, chorion
coel, coelom
ect, ectoderm
end, endoderm
gb, germ band
go, gonad
lab, labium
lg, leg
ll, lower layer
lr, labrum
malp, Malpighian tubule
max, maxilla
mb, mandible
mes, mesoderm
nc, nerve cord
neur, neuroblasts
oen, oenocytes
pb, polar body
p.lg, proleg
pr, periplasm
proct, proctodaeum
rect, rectum
ser, serosa
silk g, silk gland
som.m, somatic layer of mesoderm
sp, sperm
spl.m., splanchnic layer of mesoderm
stom, stomodaeum
stom.m., stomodaeal membrane
suboes.b, suboesophageal body
tr, trachea
vit.m, vitelline membrane
y, yolk
yc, yolk cell
ys, yolk spherule



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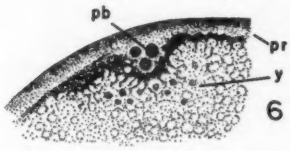

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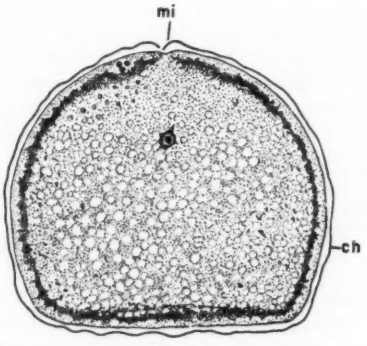

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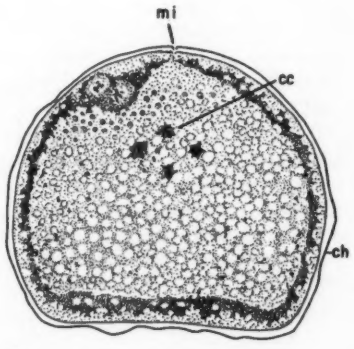

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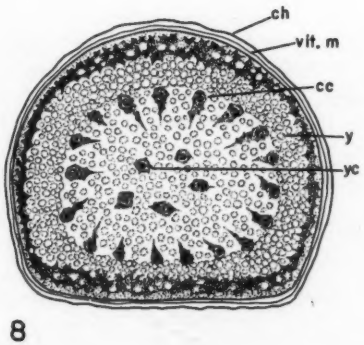

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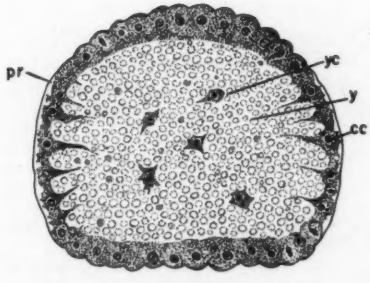

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PLATE II

When, in the latter regions, the nuclei are well established in the cytoplasm and the outer cell wall is being formed, in the broad equatorial region the tails of the comet-shaped cell masses are still evident, indicating a delayed arrival of the cells within this region (fig. 9).

In cell wall formation the outer wall is formed first and this is followed by an inward growth to form lateral walls. The inner wall is last to make its appearance. In the case of the cells along the equatorial band the inner cell wall appears along the demarcation line between cytoplasm and yolk; in the polar regions, however, the inner cell wall appears as a membrane in the yolk some distance removed from the cytoplasm. As a consequence, these cells incorporate a considerable amount of yolk when complete. The presence of the yolk has an effect on the activity of the cell in that it retards and alters cell division. When the blastoderm is complete, at about the eighth hour, cell division continues. But whereas the cells in the equatorial region divide repeatedly by mitosis, the cells in the polar regions undergo one or two amitotic divisions not accompanied by cell wall formation. These cells then are bi-, tri-, or quadri-nucleate (fig. 12). They will undergo no further multiplication but will grow laterally over the remainder of the blastoderm through a flattening-out process to become the serosa (fig. 11). The cells in the broad equatorial zone will become the germ band. The latter does not completely encircle the egg since a narrow strip of multinucleated cells divides it to connect the two polar masses of serosa cells (fig. 13). It is evident that division in the serosa cells is amitotic: in some cells the nucleus is large and lobed, in others it is sausage-shaped with a constriction indicating where fission will occur. The largest number of nuclei in a cell is four. As already pointed out, each cell has incorporated a considerable amount of yolk cut off from the main yolk mass during cell wall formation (fig. 12).

Overgrowth of the germ band by the serosa begins at 9½ hours. A break between the marginal serosa cells and the adjoining cells of the germ band permits the former to slide over the germ band (fig. 11). Growth of the serosa is very rapid and is the result of flattening of the individual cells. There appears to be no further increase in their number, nor are any cross walls evident. Slight thickenings in the serosa indicate the position of the nuclei. Two layers, cytoplasm and deutoplasm, are still present.

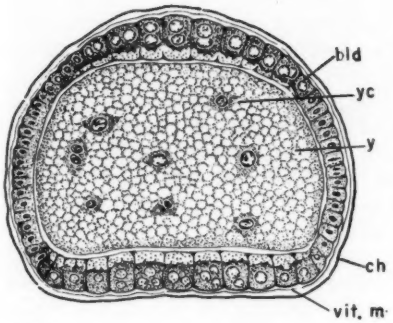
The cells of the germ band continue to increase and each cell becomes columnar in shape. What seems to be a vacuole now appears in each cell in close proximity of the inner wall. It is possibly connected with the absorption and utilization of food.

As in other Lepidoptera, the amnion makes a belated appearance. Growth of the amnion is not initiated until the serosa is complete. It arises from the ends and the lateral margins of the germ band (figs. 14 and 15). These cells become squamous and spread as a membrane over the face of the germ band. The amnion remains intact until some time after blastokinesis.

PLATE III

Explanation of Figures

Fig. 10. Blastoderm complete.
Fig. 11. Vertical section showing germ band and beginning of serosa at nine and a half hours.
Fig. 12. Same as figure 11, enlarged.
Fig. 13. Polar view of egg showing micropyle, part of serosa and germ band. Chorion removed.
Fig. 14. Vertical section showing serosa complete and the beginning of the amnion.
Fig. 15. Same as figure 14, horizontal section.



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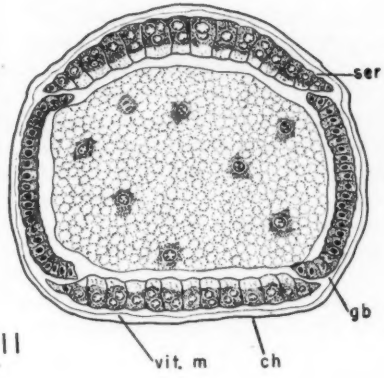

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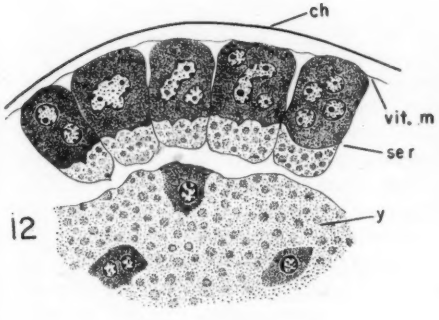

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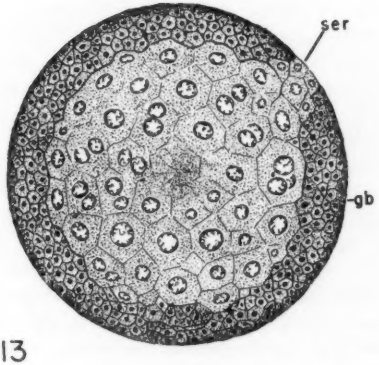

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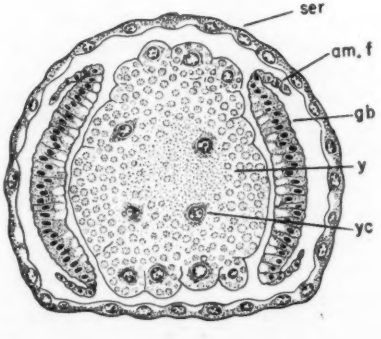

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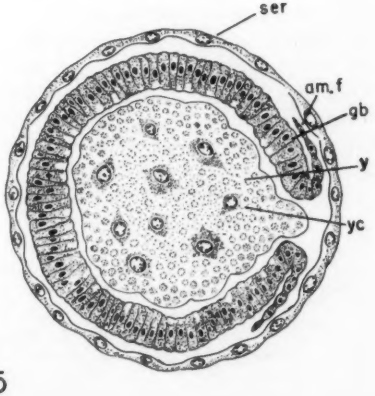

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PLATE III

At the time of the formation of the amnion, the yolk contracts and becomes more compact with a heavy concentration of granules near the periphery. The cytoplasm of the vitellophags now stains very darkly. The nucleus at this stage is much larger than the nucleus of a blastomere. A few vitellophags are binucleate. They have, however, not been observed to divide mitotically or amitotically. Hence it is assumed that the number of vitellophags remains constant during most of the period of development. Schwartze (1899) and Toyama (1902), however, report amitotic division in yolk cells while Eastham has observed frequent mitotic divisions. The yolk now becomes enclosed by a membrane which cuts into it in various places changing the smooth periphery into rounded knob-like processes. As the inward growth of this membrane continues (fig. 14), the yolk is gradually divided into a series of yolk spherules, each with one or occasionally with two vitellophags (fig. 22).

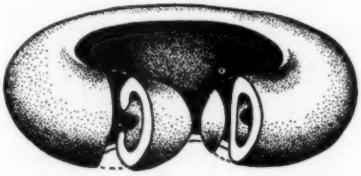
The Germ Band

The embryonic rudiment or germ band, as already pointed out, arises from the broad equatorial strip of the blastoderm. It consists of a single layer of columnar cells which on the inside comes in contact with the yolk, but on the outside is covered originally by the serosa and later by the amnion and the serosa. The rudiment is very long, the two ends nearly meeting (fig. 15). As development progresses, the margins turn into the yolk and at the anterior and posterior ends a fusion of the edges forms cephalic and caudal pouches (fig. 16). After the formation of the lower layer and the appearance of the neural groove, the anterior end enlarges to form the two prominent cephalic lobes (fig. 17). The embryo, however, retains its position during most of the period of development. Not until shortly before emergence does it become twisted. This greatly facilitates sectioning, it being possible at almost all times to obtain nearly perfect horizontal and vertical sections. Segmentation occurs when the embryo is about fifteen hours old, some time before the closure of the body wall dorsally (fig. 18). The rudiments of the head and thoracic appendages become evident ten hours later. At first the head region occupies a considerable portion of the germ band. As development progresses, the lateral walls of the germ band grow dorsally and medially until they finally meet along the median line. Simultaneously the head region loses the semblance of segmentation through consolidation of the head segments and has now become a distinct body division (fig. 19). At the same time, the abdominal prolegs become evident. The embryo now contracts and sinks deeper into the yolk, further curvature maintaining the cephalic and caudal ends in close proximity. As this process goes on, more and more yolk, which at first was almost completely enclosed by the germ band, is either taken into the midgut or is pushed toward the ventral face of the embryo between serosa and amnion. Thus the embryo becomes enclosed in an envelope of yolk which is left intact until blastokinesis has occurred. It is consumed by the embryo shortly before hatching.

PLATE IV

Explanation of Figures

Figs. 16-21. Yolk and embryonic envelopes removed.
Fig. 16. Early germ band as seen in the horizontal plane.
Fig. 17. Embryo with neural groove and cephalic lobes, as seen in the horizontal plane.
Fig. 18. Twenty-five hour embryo with segmentation complete, as seen in the horizontal plane.
Fig. 19. Sixty-five hour embryo as seen in polar view, just prior to blastokinesis.
Fig. 20. Embryo after blastokinesis, at eighty hours, polar view.
Fig. 21. Embryo shortly before hatching, polar view.



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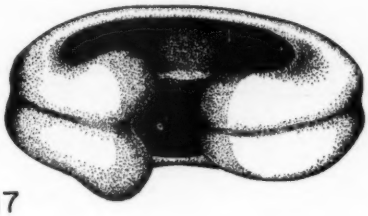

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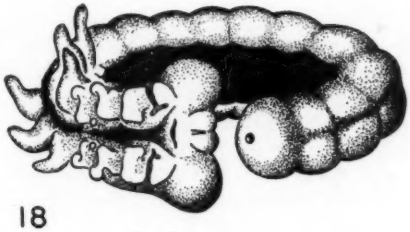

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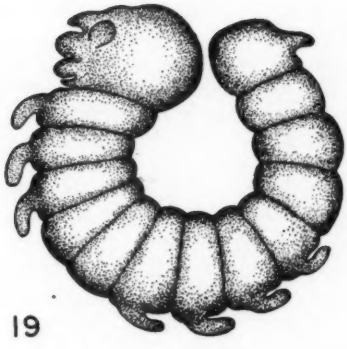

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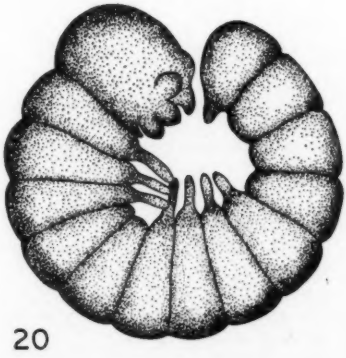

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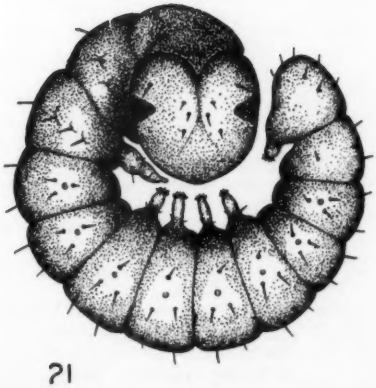

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PLATE IV

When the embryo is sixty-five hours old and the closure of the body wall is complete, it rotates along its longitudinal axis through an angle of 180°, so that the ventral surface comes to face the centre of the egg (fig. 20). It still only occupies the region in the equatorial zone. Increase in length now necessitates a change in position. In a one-hundred-hour embryo the head rotates through an angle of 90° so that its dorsal surface is now directed toward the micropylar pole and occupies the central space above the abdominal segments (fig. 21). The caudal end similarly rotates and pushes toward the centre to occupy the space beneath the head. The thoracic and abdominal segments are not visible now, being completely covered from above by the head and underneath by the last abdominal segments. This twisted position enables the embryo to occupy the maximum amount of space inside the egg. Thirty hours later it will escape from the egg shell.

Formation and Differentiation of the Lower Layer

The lower layer or middle plate is formed in a manner common in lepidopterous insects.

When the embryo is about seventeen hours old, a strip of cells along the median line of the germ band separates from the other cells of the disc and sinks below the surface. This will form the lower layer. The invagination of the germ band is initiated near the middle of the embryo and progresses both forward toward the cephalic lobes and backward toward the caudal end. The first indication of gastrulation is the appearance of mitotic divisions of the cells in the tangential plane and the disappearance of vacuoles. The cells thus change in shape from columnar to cuboidal. The presence of these dividing cells suggests that the lower layer is formed largely as the result of cell proliferation.

As the lateral plates move toward each other, the middle plate is pushed inward until it loses its connection with the germ band. When the fusion of the plates along the median line is complete, the middle plate is a distinct layer of small cuboidal cells (fig. 25). It will henceforth be referred to as the mesoderm.

Although the mesoderm at first forms a continuous sheet of cells between the ectoderm and the yolk, further lateral growth occurs segmentally resulting in distinct somatic masses. Segmentation of the ectoderm takes place when the embryo is about fifteen hours old. The neural groove and the neurogene layer which now appear (fig. 25) exert pressure on the mesoderm all along the median line. This causes the mesoderm to split into "lateral" masses.

PLATE V

Explanation of Figures

Fig. 22. Vertical section of egg with serosa and amnion complete.
Fig. 23. Section of germ band to indicate beginning of gastrulation, i.e. formation of the lower layer.
Fig. 24. Vertical section of seventeen-hour embryo, showing lower layer sinking below surface.
Fig. 25. Gastrulation complete, beginning of neurogene layer.
Fig. 26. Neurogene and dermatogene layers separate, germ band immersed in yolk.
Fig. 27. Cross section of the germ band showing nerve cord and coelomic sacs, twenty-five hour embryo.
Fig. 28. Vertical section of germ band shown in figure 27.
Figs. 29-31. Stages in the development of the stomodaeum.
Fig. 32. Horizontal section of posterior end of embryo showing proctodaeum, posterior endoderm rudiment, Malpighian tubule and beginning of rectal gland.
Fig. 33. Median sagittal section of one-hundred hour embryo showing hindgut and Malpighian tubules.
Fig. 34. Diagram of mid- and hindgut of a third instar larva.

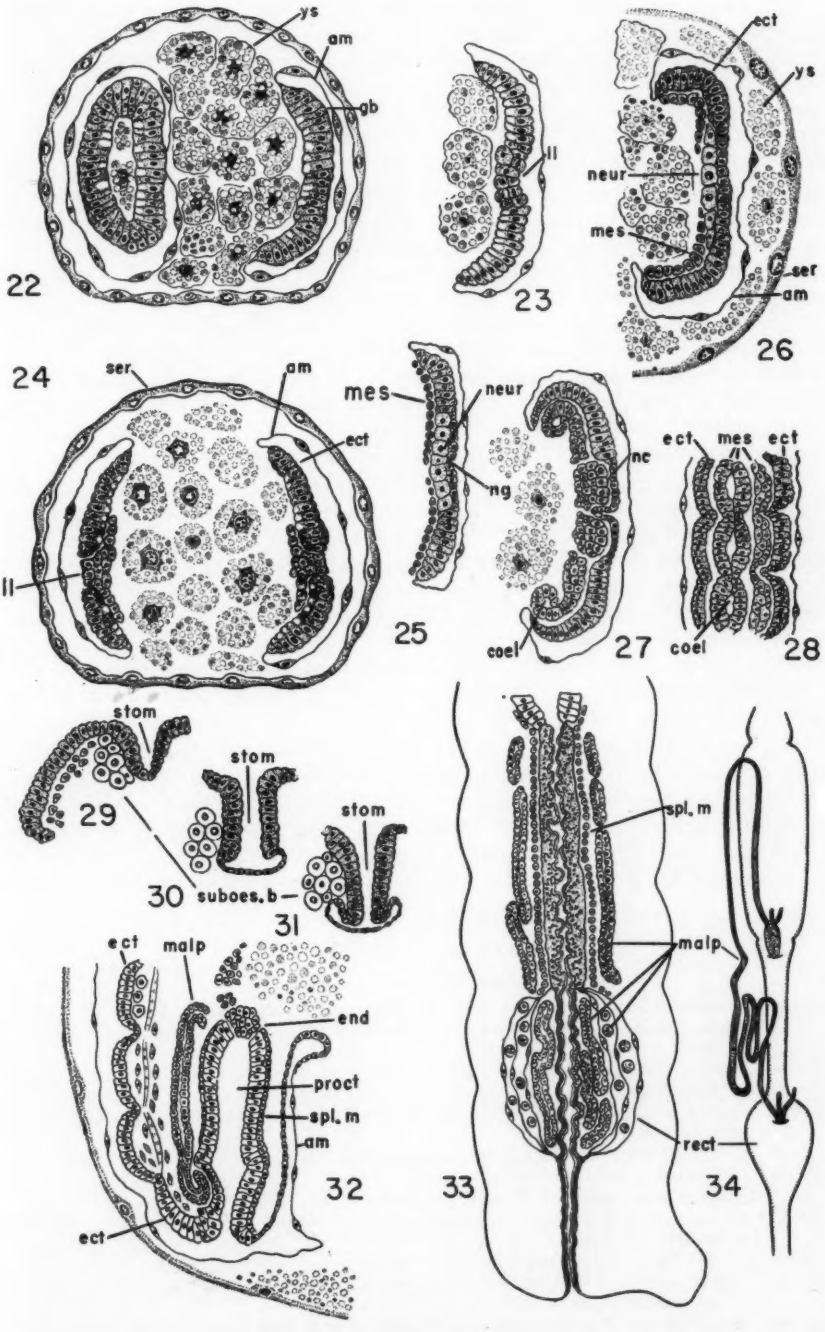
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PLATE V

In a twenty-five hour embryo the edges of the body wall (ectoderm) curve inward. The mesoderm, which is closely pressed against the ectoderm, follows suit. Finally the lateral edge of each mesodermal somite turns in to fuse with the main segment, thereby forming the coelomic sac (fig. 27). The coelom, however, exists for only a short time. It disappears with the fusion of the two layers of somatic mesoderm a few hours later.

When the embryo is twenty hours old and segmentation has already set in, the mesoderm can be seen to line the inner surface of the embryo from the cephalic to the caudal end (fig. 35). The stomodaeal and proctodaeal invaginations, now clearly evident, become enveloped by the mesodermal layer. In the region of the ventral surface of the stomodaeum the mesodermal cells enlarge and become vacuolated to form the suboesophageal body (figs. 29 and 37). The latter soon loses its connections with the remainder of the mesoderm and the overlying ectoderm, and becomes a distinctly separate body (fig. 40). As development progresses and the stomodaeum lengthens, only the dorsal surface is covered by mesoderm (figs. 40 and 41). It will not again become enveloped by mesodermal tissue until ten hours later. The proctodaeum, on the other hand, is surrounded by a mesoderm from the beginning (fig. 40).

The mesodermal covering of the mesenteron has a double origin. As the anterior mesenteron rudiment grows caudad, mesoderm of the last gnathal segment extends inwards to press laterally against the endodermal rudiment. As the latter grows backward and ventrad to form the anterior end of the midgut "trough", the mesoderm accompanies it (figs. 43 and 44). The posterior endodermal rudiment, which grows forward from the proctodaeum in the form of two arms, is covered on the outside by mesoderm which is continuous with the mesodermal envelope of the proctodaeum. The arms of the posterior endoderm rudiment with the accompanying splanchnic mesoderm grow forward and ventrad to form the posterior end of the midgut trough.

In a sixty-hour embryo (fig. 41) the body begins to close dorsally. The closure begins first in the posterior region and moves forward progressively, the ectoderm replacing the amnion which provided a temporary closure. The lateral sheets of mesoderm do not meet dorsally until a few hours after the ectoderm is complete. About ten hours later, the endodermal lining of the midgut also grows dorsad to effect a closure, followed by the splanchnic mesoderm which,

PLATE VI

Explanation of Figures

Fig. 35. Horizontal section of germ band at twenty hours, showing beginning of segmentation, stomodaeum, proctodaeum, ectoderm, neurogene layer, and mesoderm (lower layer).
Fig. 36. Vertical section through the cephalic end of the germ band at forty-five hours.
Fig. 37. Suboesophageal body, showing vacuolated cells.
Fig. 38. Section of sixty-hour embryo through distal end of stomodaeum showing anterior endoderm rudiment.
Fig. 39. Section of body wall and embryonic envelopes of sixty-hour embryo, enlarged.
Fig. 40. Horizontal section of sixty-hour embryo.
Fig. 41. Embryo as in figure 40, the egg cut in the vertical plane.
Fig. 42. Three dimensional view of embryo shown in figure 40. Mesoderm, yolk and embryonic envelopes omitted.
Figs. 43 and 44. Developing midgut of sixty-hour embryo.
Fig. 45. Sagittal section of midgut of embryo shown in figure 40, the section cut to one side of the median plane.
Fig. 46. Section of caudal end of seventy-hour embryo indicating method of closure of dorsal wall and midgut. Note that blastokinesis has set in.

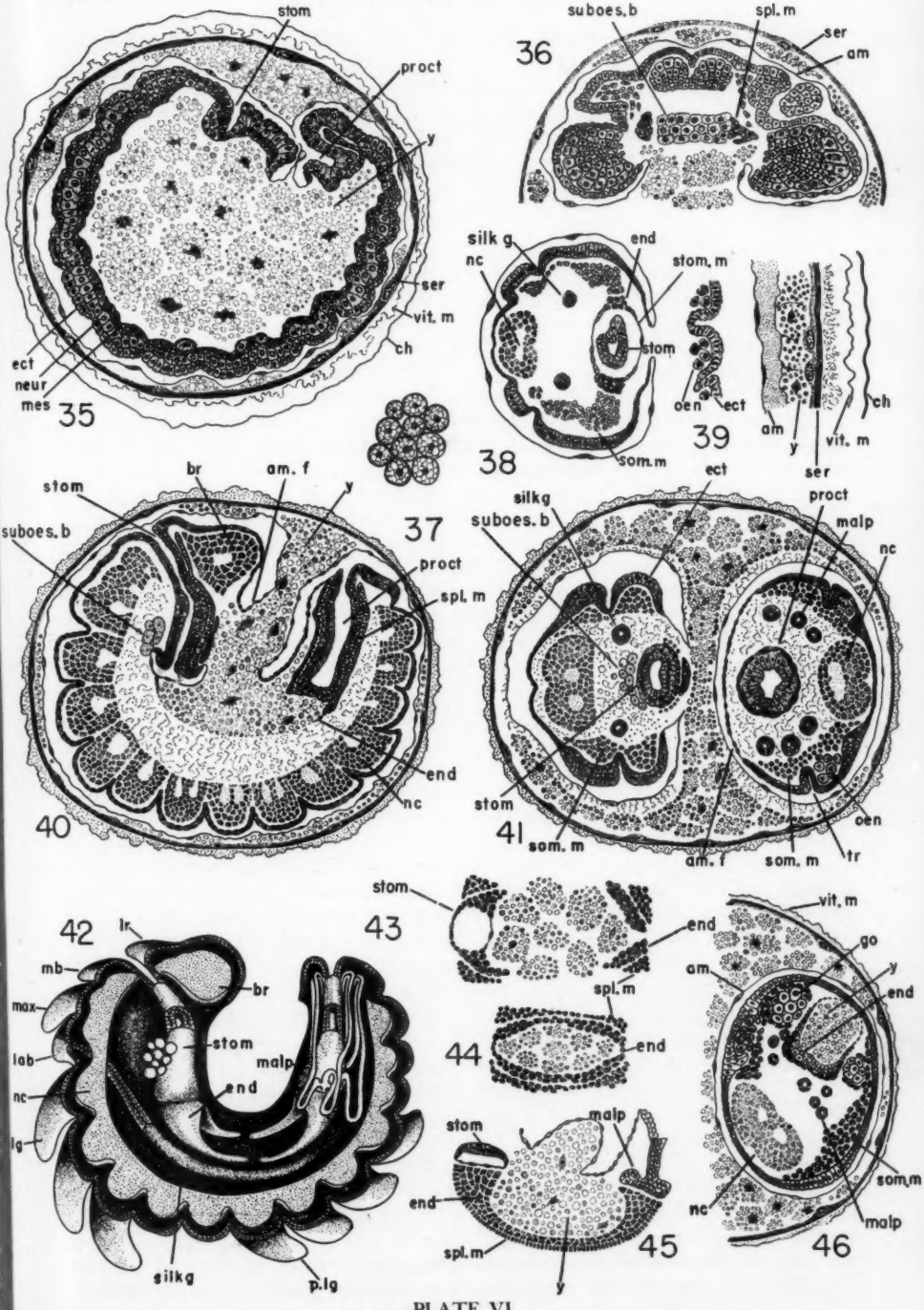
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PLATE VI

however, lags slightly behind. A considerable amount of yolk is retained in the midgut (fig. 46).

Blastokinesis now occurs, beginning at the posterior end and moving forward progressively as the body wall closes dorsally. Fig. 46 shows such a stage. Posteriorly the embryo has rotated through an angle of almost 180° so that the ventral surface faces inward, while the anterior end is still in the position shown in fig. 41.

The Ectoderm

The ectoderm is the first of the three embryonic layers to be formed. The two internal embryonic layers, mesoderm and endoderm, will be derived from it. In addition, the ectoderm will give rise to a series of important structures of its own.

The original function of the ectoderm is to form a protective cover. Hence the epidermis of the insect body wall, with its hairs, setae, tracheal invaginations, apodemes, etc. is ectodermal in origin. The cuticular cover of the insect is a product of ectodermal secretion. The formation of the blastoderm, the growth of the lateral plates, and the closure of the body wall have already been mentioned and need not be described here.

The second basic function of the ectoderm is to enable the organism to communicate readily with its environment. Originally the sensory cells are in close association with the other ectodermal cells, both embryologically and phylogenetically. With increase in complexity, the greater part of the nervous system migrates inward to form the brain and nerve cord. In *Mamestra configurata* a neurogene layer appears when the embryo is about twelve to fourteen hours old. Until now the divisions in the blastoderm cells have been in a plane perpendicular to the surface. At this time a number of cells along a median strip of the germ band divide in a plane parallel to the surface. The ectoderm thus becomes two-layered in this region. The outer or dermatogene layer consists of small cells, while the inner, the neurogene layer, is made up of large cells (fig. 25). Shortly afterwards, when the embryo is about fifteen hours old, the neurogene layer becomes separated from the ectoderm (fig. 26). In a longitudinal section of an embryo twenty hours old the neurogene layer can be seen extending through the entire length of the embryo lying between the ectoderm on the outside and the lower layer of mesoderm on the inside (fig. 35). Further detailed study of the nervous system has not been made. However, in a forty-five hour embryo the ganglia of the nerve cord are well developed. At this time, too, active cell division takes place in the cells of the cephalic lobes ("brain"). Fig. 36 shows these cells in rows with some of the outermost cells in the process of mitotic division. In a sixty-hour old embryo (fig. 40) the nervous system is clearly differentiated into a suprastomodaeal brain, three fused gnathal ganglia, three thoracic and nine abdominal ganglia.

The third important function of the ectoderm is to give rise to parts of the alimentary canal. The stomodaeal and proctodaeal invaginations are first clearly observed as shallow depressions in the ectoderm of a twenty-hour embryo. At this time, the embryonic rudiment is long, with the cephalic and caudal ends almost in contact (fig. 35). Both invaginations grow rapidly inward and in the sixty-hour embryo (fig. 40) they are seen to extend deeply into the interior. Figs. 29 to 31 indicate a sequence of events in the formation of the stomodaeum. The shallow pitlike invagination gradually deepens and becomes tube-like. While the cells of the wall remain columnar throughout, those at the end become cuboidal. As development progresses, they become gradually more flattened to form the stomodaeal membrane. The invagination of the ectoderm is accom-

panied by an ingrowth of the lower layer (mesoderm). Since the mesoderm cells along the ventral surface of the stomodaeum become separated as the suboesophageal body (fig. 40), the stomodaeum is at first only partially covered by the mesoderm, namely along the dorsal surface (figs. 40 and 41).

As the proctodaeal invagination occurs, underlying mesoderm is carried along. Thus the hindgut is from the beginning enclosed by a mesodermal cover. When the proctodaeal invagination is still quite shallow, two lateral outgrowths from the lower end give the first indication of the Malpighian tubules. Each of these lateral outgrowths divides into three branches, the tubules. These tubules grow rapidly backward, the distal end of each penetrating the epithelial lining at the posterior end of the proctodaeum (fig. 32). In the forty-five hour embryo the Malpighian tubules are stout and only as long as the hindgut. During the next five hours they will become greatly lengthened. In a fifty-hour embryo they extend first forward laterally to the developing midgut, and then backward to what will be the rectum. As development progresses, the tubules will continue to increase in length and become further coiled. This process will extend also to the portions that have penetrated the wall of the rectum. This is clearly seen in a sagittal section of a one-hundred-hour embryo (fig. 33).

Tracheal invaginations with their accompanying oenocytes are evident in a fifty-five hour embryo. A further study of these has not been made. The apodemal invaginations have not been investigated.

The Endoderm

It is generally accepted that in insects the midgut epithelial lining is derived from endoderm. The origin of the endoderm, however, has been the subject of much controversy. Most embryologists assume that the endoderm arises from two widely separated groups of cells, the anterior and posterior rudiments respectively, which at one time form part of the lower layer. Although the writer has no intention of adding further to the controversy, he thinks that in this species the "endoderm" is at no time part of the lower layer. The material on hand suggest that the anterior endoderm rudiment arises from ectodermal cells on either side of the distal end of the stomodaeum (fig. 38), while the posterior rudiment is derived from ectodermal cells that form the distal closure of the proctodaeum (fig. 32). This is at variance with what Gross and Howland (1940) find in *Prodenia*, another noctuid, but agrees fairly well with the findings of other recent workers on lepidopterous insects, notably Johannsen (1929) and Richards (1932). The writer is inclined to accept Richard's view:—

> "that whatever cells in each particular case happen to be appropriately located at the time when the endodermal strands are due to be formed, those cells will be 'determined' to form the midgut anlage, and subsequently differentiate into the structure typical of midgut epithelium. The question is purely a matter of time of determination of the parts involved. . . ."

The anterior rudiment grows backward in the form of two arms to meet the forward growing arms of the posterior rudiment (fig. 42). When a fusion has been achieved, ventrad growth results in the formation of the midgut trough. Proliferation of the endodermal cells is accompanied by a corresponding proliferation of the mesodermal cells. Dorsal closure of the midgut is accomplished when the embryo is seventy-five hours old.

The Mesoderm

The appearance of the mesoderm in the form of the lower layer has already been described. The appearance of the mesodermal somites, coelomic sacs,

somatic and splanchnic layers has been mentioned. The origin of the suboesophageal body has been discussed. The differentiation of mesoderm into muscle has not been investigated. Although the gonads are clearly seen in the fifth abdominal segment of a seventy-five hour embryo, their early development and subsequent changes have not been investigated. Nor has a study of the origin of the circulatory system been made.

Fate of the Embryonic Envelopes

As in Lepidoptera in general, the serosa is the first of the embryonic membranes to appear, the amnion not being formed until the former has completely covered the germ band. The amnion, as already pointed out, arises from the inflexed edges of the germ band. Whereas the serosa, throughout its existence, retains the appearance of a cellular layer, the amnion, almost as soon as formed, assumes the appearance of a membrane. In early embryonic development, the amnion is in proximity to the serosa, but with subsequent growth of the germ band, yolk is forced between the two embryonic envelopes.

Although the amnion at first covers only the ventral face of the germ band, as development of the latter continues, amniotic folds extend over the edges and ultimately fuse along the future dorsal median line of the embryo. Part of the amnion thus forms a temporary dorsal body closure. Whereas the cells of the main amniotic envelope are greatly flattened and widely spaced, the cells that close the body wall become rounded and closely spaced. Whether these cells take part in the formation of the definitive body wall or whether they are replaced by ectodermal cells, has not been determined.

After blastokinesis the embryo develops for a time at the expense of the yolk retained in the midgut. When this is used up, the amnion is ruptured and the extra-embryonic yolk is consumed. Growth is now very rapid. Further change in position makes it possible for the embryo to occupy the entire space within the egg. Just prior to hatching the embryo is enclosed by the chorion, the vitelline membrane and the serosa. The serosa now has lost all semblance of a cellular layer and appears as a thin membrane. It is, however, not consumed prior to hatching, as is the case in *Diacrisia*. When the embryo is about 130 hours old, it sets itself free by rupturing the serosa, the vitelline membrane and the chorion.

Summary

The main features of the embryology of *Mamestra configurata* are described.

The egg is .45 mm. in diameter, spherical in form, with a dorsal micropyle. The eggs are laid in a mass of one hundred to one hundred and fifty, in a regular pattern. Fertilization takes place within the second half hour after oviposition.

The comet-shaped cleavage nuclei reach the periplasm first in the polar regions where they form multinucleate cells, the future serosa. The embryonic rudiment is like a broad band at the equator of the egg. The amnion appears after the completion of the serosa and arises from the edges of the germ band.

Gastrulation involves the invagination of a narrow strip of proliferating cells along the median line of the germ band. With the fusion of the two lateral plates (ectoderm), the layer is pushed inward to spread over the inner surface of the germ band. It forms the mesoderm.

The epithelial lining of the midgut is at no time part of the lower layer. It is derived from the blind ends of the stomodaeum and the proctodaeum. The mesodermal covering of the midgut arises anteriorly as an extension of the somatic mesoderm of the last gnathal segment and posteriorly as an extension of the mesoderm that covers the proctodaeum.

The Malpighian tubules arise as lateral outgrowths from the proctodaeum. When the embryo is about forty hours old, the ends of the tubules become closely pressed to the epithelial lining of the hindgut to form the rectal gland.

Segmentation sets in at fifteen hours. Ten hours later the gnathal and thoracic appendages are clearly differentiated, although the abdominal prolegs are not yet evident. Closure of the body wall begins at the caudal end of the embryo at sixty hours. Prior to closure, a considerable amount of yolk is taken into the midgut.

Blastokinesis, involving a rotation of the embryo through an angle of 180°, occurs at seventy hours. It begins at the posterior end and moves forward progressively following the closure of the dorsal body wall. When the yolk enclosed in the midgut is used up, the amnion is ruptured and the remainder of the yolk consumed. Growth is now very rapid, increase in length being made possible by a change in the position of the embryo. Hatching occurs at one hundred and thirty hours.

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A Previously Unrecognized Species of *Nymphula* (Lepidoptera: Pyralidae)[1]

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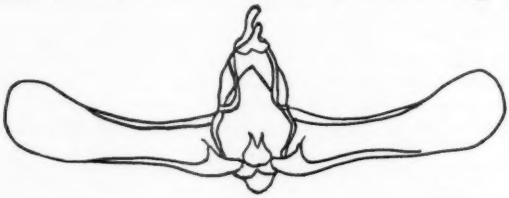
Study of the series placed in the Canadian National Collection as *Nymphula badiusalis* (Walker) revealed that it consisted of specimens of two closely similar species. The original descriptions are sufficiently detailed to indicate that one of these is *N. badiusalis* and that the other is *N. curviferalis* (Walker), which has been considered a synonym of *N. badiusalis*. The following brief descriptions will permit separation of the species.

***Nymphula badiusalis* (Walker) (Plate I, Figs. 1, 2; text Fig. 1)**

Cymoriza badiusalis Walker, 1859: 955.
Oligostigma albalis Robinson, 1869: 153, pl. 1, fig. 3.

Wings white, fore wings dusted to a varying extent with brown, the dusting often concentrated to form a dark costal streak. Fore wings with basal line



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Text Fig. 1. *Nymphula badiusalis* (Walker). Male genitalia, aedoeagus omitted.
Text Fig. 2. *Nymphula curviferalis* (Walker). Male genitalia, aedoeagus omitted.

oblique, black, usually incomplete; reniform typically rectangular, black, filled with white, but portions may be obsolete, leaving a longitudinal streak or a pair of transverse lines; postmedial line fuscous or dark brown, running perpendicularly from costa to M_2, then acutely angled and extending inward past the discocellular mark, which it touches, to the middle of the wing, where it is again angled so as

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PLATE I

Fig. 1. *Nymphula badiusalis* (Walker). Male.
Fig. 2. *Nymphula badiusalis* (Walker). Female.
Fig. 3. *Nymphula curviferalis* (Walker). Male.
Fig. 4. *Nymphula curviferalis* (Walker). Female.

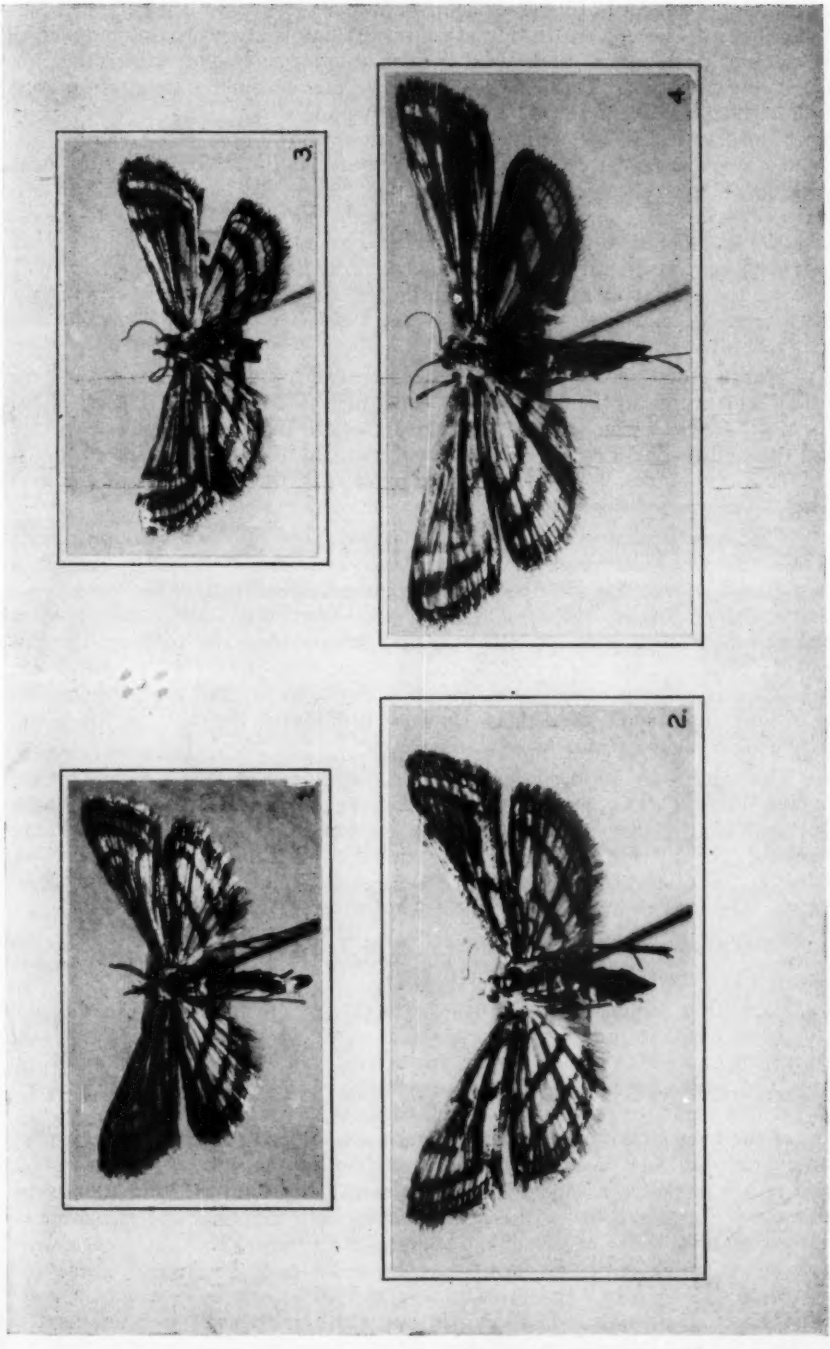

PLATE I

to proceed obliquely to the posterior margin, finally joining a black streak which follows this margin to the base; the postmedial line is attenuated or interrupted at its outer angle and is relieved by yellow scales at this point; subterminal line black or dark brown, curving evenly, parallel to the outer margin from costa to inner margin except at Cu_2, where a long spur extends basad to approach or meet the postmedial line; terminal area orange-yellow, bordered inwardly, and sometimes outwardly, by a black line; fringe gray, basal half darker. Hind wing with an oblique, obsolescent, black basal line; postmedial and subterminal lines black or dark fuscous, parallel to each other except anteriorly, less strongly curved than the terminal band, so that the subterminal gradually approaches the terminal anteriorly and posteriorly; terminal band yellow, bordered on both sides with fuscous, the external border undulating, cutting off little yellow crescents at the margin; fringe pale gray with a dark-gray basal line, the whole darkened at irregular intervals.

Walker's description mentions the brown bands of the hind wing and the strong curvature of the subterminal band of the fore wing. He described *badiusalis* from Canada (probably Ontario), where this is the common species, and I have little doubt of the correctness of the identification. Robinson's figure of *albalis* also agrees, except in the configuration of the black lines of the hind wing; I believe that this represents merely a mistake in delineation.

The male genitalia are closely similar to those of *Nymphula stratiotata* (Linnaeus), from Europe, as figured by Pierce and Metcalfe (1938). Tegumen very broad; uncus finger-shaped, faintly carinate distally; gnathos prominent, blunt, without spines; vinculum narrow, prolonged into a short saccus; juxta weak, ovate, bilobed dorsally; valve long and narrow, obliquely truncate, margins roughly parallel; costa narrowly inflated to about four-fifths, faintly emarginate; sacculus with a flange at base which bears one or two papillae, each surmounted by a seta; these papillae reaching about two-thirds of the way to the costal margin; aedoeagus irregularly bent, unarmed.

This species is abundant and widely distributed in the eastern part of Canada. The C.N.C. has specimens from Prince Edward Island; southern Quebec; Ontario: from the Ottawa region and Bobcaygeon south to Point Pelee; Manitoba: Aweme and Wabowden, the latter locality being on the Hudson Bay Railway; there are also specimens from Augusta, Maine, and Westville, New Jersey. Dates of capture are from late June to early September.

***Nymphula curviferalis* (Walker) (Plate I, Figs. 3, 4; text Fig. 2)**

Oligostigma curviferalis Walker, 1865: 1331.

Maculation in general closely similar to that of *N. badiusalis*. Fore wings with basal line less prominent; discocellular mark a brown, transverse streak; postmedial line yellow-scaled almost throughout its course, angled inward just above Cu_2, instead of at M_2; subterminal line brown, filled medially with yellow, with only a slight inward projection in the anal fold; fringe with a chain of dark dots at the base. Hind wings with antemedial line barely indicated; postmedial and subterminal lines curved, parallel to each other, and also to the marginal band except at the costal and anal margins, which the marginal band follows to meet the submarginal; hence the interspace between marginal and submarginal bands is of even width except at the ends, where it tapers abruptly, whereas in *badiusalis* it is crescentic in form; the postmedial and subterminal bands are brown, the former with a few orange scales, the latter with heavy orange scaling medially; terminal bands as in *badiusalis*, but with the external black line hardly crenulate and not followed by yellow scales, so that a line of gray scales replaces

the series of yellow crescents of *badiusalis*; the dark-gray line in the base of the fringe is strongly darkened at its intersection with each vein.

Walker specifically mentions the ochraceous scaling of the subterminal line; the linear, brown discocellular mark; and the course of the subterminal line on both fore and hind wings. The identification may be regarded as definite.

Male genitalia closely similar to those of *badiusalis*. Uncus more gradually tapering, hardly exceeding the gnathos; juxta proportionally larger; valves shorter in proportion to their width, sacculus hardly expanded at the base; the seta-bearing papillae arising from the inner surface of the valve distinctly above the sacculus, and directed mesad, not dorsad as in *badiusalis*; in the C.N.C. specimen there are two papillae on the right valve and one on the left.

There are in the C.N.C. only two specimens of *curviferalis*, both from southern Ontario. These are: a male, taken at Teeswater, Ont., on July 20, 1949, by D. F. Hardwick; and a female, taken at Strathroy, Ont., on July 8, 1926, by H. F. Hudson. There are several additional specimens in the Lyman Collection, at the Redpath Museum, McGill University, Montreal; these come from the Montreal region and from various localities on the Richelieu watershed; all were taken in July. The description of *badiusalis* given by Forbes (1923, p. 578) is evidently based in part on specimens of *curviferalis*, and this species is no doubt more common south of the International Boundary.

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Organization of a Lepidopterists' Society

We are requested by Dr. F. H. Rindge, Assistant Curator of the Department of Insects and Spiders in the American Museum of Natural History to announce the organization of The Lepidopterists' Society. Officers of this Society include Dr. J. H. McDunnough as President, Mr. A. H. Clark, Senior Vice-President, Mr. J. B. Ziegler as Treasurer and Dr. F. H. Rindge as Secretary. The first annual meeting of the Society was held at the American Museum of Natural History, New York 24, N.Y., on December 29th and 30th. All members and interested parties are cordially invited to attend the meetings of the Society.

THE EDITOR.

Further Effects of the Defoliation of *Cordia macrostachya* (Jacq.) R. and S.

By F. J. SIMMONDS
Commonwealth Bureau of Biological Control

In connection with an attempt at the biological control of the weed *Cordia macrostachya* in Mauritius (see Simmonds 1948) information was required as to the effect on the plant of periodic defoliation similar to that caused by leaf-eating beetles, two species of which showed promise for introduction from the West Indies against the weed. In spite of the obvious general importance of the effect that defoliation by insects has on plants very little work has been done to determine in any particular case the manner in which a plant reacts to damage of this nature. With *Cordia* it was particularly important to ascertain what effect, if any, defoliation has on inflorescence and seed production.

In his investigation of the possibilities of the biological control of rag-wort, *Senecio jacobaea* L. Cameron (1935) obtained data on the effects of both natural and artificial defoliation on seed production and on the recuperative powers of the plant. Defoliation entailed reduction in seed production, possibly death of the plant under poor soil conditions, or sometimes a prolongation of life of the plant by induction of formation of young shoots, and sometimes a retardation in ripening of the seed.

Results obtained from previous work on cereals are conflicting. Lyubimenko, Eidel'man, Schevchenko, etc. experimented with defoliation of cereal plants at different stages and with various degrees of intensity. In some of these experiments the plant was reported to be stimulated, and the grain yield increased, by removal of a small proportion of the leaf surface.

It is obvious that some idea should be obtained as to what happens with *Cordia* when light and heavy defoliation occurs, since if, as seems unlikely, light defoliation leads to increased seed production the introduction of leaf-eating beetles into Mauritius might result in the stimulation of the weed rather than in any degree of control. Some results on this point have already been obtained by Callan (1948). In his experiments the larger leaves only were removed from a number of *Cordia* bushes at weekly intervals, an equal number of similar bushes being left untouched as controls. Removal of leaves reduced the number of inflorescences formed in eight weeks from 35.8 to 15.9 per plant and reduced their average length from 8.9 cms. to 5.0 cms.; flowerbuds produced decreased from 564 to 219 per plant, and fruits from 171 to 16.2. Hence the effect of defoliation on *Cordia* with respect to fruit production is clearly seen.

With these results as an indication of one effect of defoliation on *Cordia* it was felt desirable to determine what other effects, if any, on the growth of the plant resulted from defoliation,—whether leaf-production and general growth of the plant were affected.

It was decided to defoliate a bush once a month and to make a number of measurements over a long period. A second similar bush was to have half its leaves removed monthly, and a third was to remain untouched as a control. It is fully realized that results from individuals are not as reliable as those representing an average for a number of bushes, but in view of the measurements taken it would have been impossible to make the experiment on a larger scale with the time available. Hence out of a number of *Cordia* bushes that had been planted some months before in large galvanized iron containers three were selected as nearly as possible the same size (about 3 ft. high 2 ft. in diameter) and in a

similar stage of growth. These were placed on a concrete platform at the periphery of a large samaan tree so that they were partially shaded during the middle part of the day. In the dry season the plants were equally and adequately watered daily.

These experiments were started on April 1st, 1947, and on that date and on the first of every subsequent month (or nearest day convenient) until January 1948 leaves were removed and observations recorded. The entire operation consisted of:—

1. Cutting leaves off at the petiole. From plant 1 all leaves over 1 cm. in length were removed each month, and from plant 2 only alternate leaves were removed. Starting from the lowest leaf on each branch only alternate leaves were removed going right up the whorl of leaves to the point where they became less than 1 cm. long. Hence the tips of the branches were not touched.

2. Each of these collections of leaves was counted and weighed both fresh and after drying. (Dried to constant weight at 100°C.).

3. The diameter of all three plants at a given point 10 cms. above soil level was recorded each month.

4. The lengths of all the branches over .5 cm. in diameter were measured from the junction with the main stem to the point where they were only .5 cm. in diameter (each branch being labelled).

5. All inflorescences .5 cm. long or over were removed each month and the number of flowers and buds and also fruits were counted. Any dead inflorescences were also noted.

6. In January 1948 measurements were made on the three plants of the length of branch taken up by one whorl of leaves (5 leaves in a whorl).

These results are shown in condensed form in Table 1, and the effects of defoliation are well marked. The bush from which half the leaves were removed is intermediate in all respects between the control and the plant which was completely defoliated. Where complete defoliation occurred monthly the plant in the 10 months produced 5777 leaves, wet weight 1175.9 gms., dry weight 246.4 gms. Half defoliation gave a total of 1552 leaves, wet weight 985.9 gms. dry weight 232.4 gms. Therefore, although the number of leaves produced in the former case is nearly four times that of the latter the wet and dry weight of these are not dissimilar. Unfortunately it was impossible to ascertain what weight of leaf was produced by an untreated plant in the same period.

Considering the diameter of the main stem and that of the laterals it is apparent that in the ten month experimental period defoliation has a very marked and similar effect on both these characters. Also the restriction of growth is shown in the shortening of the length of stem bearing each whorl of leaves. The untouched control plant showed approximately 50% increase in both diameter of main stem and thickness of laterals, whereas the defoliated plants showed considerably less.

Reproduction was also considerably affected. After the first defoliation there was an indication that *increased* flower production occurred. This would not be unusual, since a number of plants are known to respond to temporary unfavourable conditions by a period of increased flower production. However, the effect of continued defoliation was soon very pronounced. After the third month no flowers were produced on either of the defoliated plants, though inflorescences were produced steadily on the control plant. Before inflorescence-production ceased entirely there was a stage where rudimentary inflorescences were formed but never expanded, and died whilst still less than .5 cm. in length.

TABLE I

Effect on various characters of complete and partial defoliation of *Cordia* bushes each month.

1. Complete defoliation 2. Half defoliation 3. Control — no defoliation.

Date	No. of leaves removed			Wet weight of leaves removed			Dry weight of leaves removed			Diameter of stem 10 cms. from soil level		
	1	2	3	1	2	3	1	2	3	1	2	3
April 1	383	173	—	172.1	116.5	—	46.3	30.6	—	1.9	1.8	2.0
May 1	465	183	—	105.4	125.5	—	26.1	26.3	—	2.0	1.9	2.2
June 2	567	178	—	138.0	99.7	—	29.0	23.8	—	2.0	1.9	2.3
July 2	492	118	—	136.0	96.0	—	28.8	23.8	—	2.0	2.0	2.4
August 6	586	132	—	122.7	99.4	—	24.5	21.4	—	2.0	2.0	2.5
September 6	558	153	—	95.0	96.0	—	16.9	23.5	—	2.0	2.1	2.6
October 6	643	132	—	120.0	64.5	—	19.7	18.8	—	2.0	2.1	2.7
November 6	615	185	—	103.3	109.2	—	19.1	23.4	—	2.0	2.1	2.8
December 5	688	172	—	86.7	94.9	—	16.0	20.3	—	2.0	2.2	2.9
January 6	780	126	—	96.7	84.2	—	20.0	20.5	—	2.1	2.2	3.0

Date	Average diameter of laterals over .5 cm. in diameter			Total Inflorescences			Average length of inflorescences			Total buds, flowers and fruits			Average per inflorescences		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
April 1	.80	.95	.81	20	23	6	3.7	4.1	4.2	493	446	429	34.6	18.5	7.1
May 1	.85	1.02	.91	14	11	8	1.1	3.2	5.3	946	631	575	67.6	57.4	71.9
June 2	.88	1.02	1.00	?	?	?	?	?	?	?	?	?	?	?	?
July 2	.91	1.02	1.04	29*	8*	10	5.5	5.5	7.2	?	?	346	?	?	34.6
August 6	.92	1.02	1.09	—	—	8	—	—	4.2	—	—	263	—	—	32.9
September 6	.95	1.12	1.13	—	—	6	—	—	3.9	—	—	130	—	—	21.7
October 6	.96	1.12	1.17	—	—	4	—	—	3.1	—	—	26	—	—	6.5†
November 6	.99	1.15	1.19	—	—	4	—	—	2.4	—	—	40	—	—	10.0
December 5	1.00	1.20	1.21	—	—	2	—	—	3.7	—	—	42	—	—	21.0
January 6	1.00	1.22	1.24	—	—	—	—	—	—	—	—	—	—	—	—

*Inflorescences dead when very small.

†Insect damage occurred.

Length of stem for one whorl of leaves January, 1948.

Plant 1. 0.9 cm. (.7 — 1.2)

Plant 2. 3.4 cms. (2.7 — 4.5)

Plant 3. 8.1 cms. (5.6 — 10.5)

Thus complete and half defoliation each month considerably reduces both the growth and reproductive power of *Cordia*, and if it is possible by means of introduced phytophagous insects to achieve in Mauritius a similar degree of periodic defoliation the check to the present vigorous growth and dispersal power of *Cordia* in the island should be considerable.

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The Entomological Society of Canada

The present number of this journal marks an important event in Canadian entomology: the rebirth of a Canadian entomological society of a truly national character.

We say "rebirth" and not "foundation" advisedly. As the early records show, a group of twenty-five persons meeting on the 16th of April, 1863 in Toronto, organized an Entomological Society of Canada, under the Presidency of Professor H. Croft, with Mr. W. Saunders as Secretary-Treasurer and the Rev. Prof. Hubbert as Curator. Canada then consisted only of the Provinces of Ontario and Quebec, bound by an Act of 1840 in a somewhat uneasy union: so that the progenitor of our national society actually came into existence before Confederation (1867).

Under the name of the Entomological Society of Canada the organization flourished for a number of years. In 1864 branches were formed at Quebec City in "Canada East" and in London, in "Canada West"; and a preliminary list of Canadian Lepidoptera, comprising 144 species, was published. In 1865 a further list of Lepidoptera, including 350 more species, was issued. In 1866 the work of the Society was seriously interrupted by the Fenian Raid—an effect that seems rather out of proportion to the military significance of that rather bloodless campaign. However, by 1867 the Society had resumed work with renewed vigor, issuing a list of Canadian Coleoptera including 55 families, 432 genera and 1231 species. In 1868 it resolved to make a permanent record of its labours and published, on August 1 of that year the first number of the first volume of *The Canadian Entomologist*, under the Editorship of the Secretary, the Rev. C. J. S. Bethune. Thus *The Canadian Entomologist* first saw the light as the official organ of the Entomological Society of Canada.

However, though during these early years the Society had made very solid progress with the support of the members alone, it soon became evident that financial assistance from other sources was necessary. In December 1869 this was provided in the form of a grant of $400 for the year 1870 by the Board of the Agricultural and Arts Association of Ontario, on condition that the Society furnished an Annual Report, formed a cabinet of insects useful and prejudicial to agriculture and horticulture and continued the publication of *The Canadian Entomologist*. In 1871 the grant was increased to $500 and the Society was incorporated under a new section of the Agricultural Arts Act (Section 33 of 31 Vict., c. 29) as "The Entomological Society of Ontario". This legal connec-

Plant 2. 3.4 cms. (2.7 — 4.5)
Plant 1. 0.9 cm. (.7 — 1.2)
•Inflorescences dead when very small.

tion between the grant made by the Province of Ontario to the Society and its official designation as an Ontario organization, has been one of the chief difficulties encountered in the attempt to reestablish the Entomological Society of Canada. Through the efforts of our President, Mr. W. A. Ross, and our Vice-President, Professor A. W. Baker, and the members of the Committee set up to study this question the problem was happily solved by recognizing the joint responsibility of the Entomological Society of Ontario in the publication of *The Canadian Entomologist*, its responsibility for the continuation of the Annual Report and its custodianship of the library.

The reestablishment of a truly national entomological Society has, it is clear, been ardently desired by all Canadian entomologists. This has now been accomplished. But when we look back over the period of a long life-time to the early years of the Society, and consider what our predecessors accomplished with their scanty membership, their meagre technical resources, the limited time at their disposal and their inadequate means of transport, we cannot feel more than a very slight satisfaction with our own efforts.

We rightly value and appreciate our indispensable Government subsidy; but our Treasurers may well look back with envy on the grant the officers succeeded in obtaining in 1871. We think we do well to publish twelve numbers of twenty pages in an issue of 1000 copies and wonder whether we can keep up the pace; but in the last number of the second volume the Editor already states that he will publish monthly numbers of the same size. In the Editorial to the first number of Volume III, the printing and distribution of 1000 copies to be distributed to all who seem likely to subscribe or to join the Society, is announced. Club rates for subscribers are organized. *The American Agriculturist* and *The Canadian Entomologist*, costing $2.50 if purchased separately, will be supplied together for $2.50. Equally advantageous combinations with Arthur's *Home Magazine* and the *Children's Hour* are also advertised. A little later the Society undertakes the sale of entomological pins, cork and labels. It arranges excursions and annual picnics and allots prizes for entomological collections. At an early date the Society established widespread and distinguished connections. Its first honorary members were the Baron von Osten Sacken, Herman Hagen the teacher of John Henry Comstock and Asa Fitch. Cresson, Grote, Lintner, Riley, Scudder and Francis Walker were among the early contributors. The printing of many of these volumes is very respectable and some contain plates any modern author would be pleased to see in his papers. The members of the first Entomological Society of Canada lacked the extensive and intensive training available to us. But there is no doubt that the broad classical education evidenced by their writings fitted them well for the varied work involved in founding entomology in Canada. Their knowledge of natural history was extensive; they ranged with surprising success over a wide field; they were fertile in ideas; and they possessed the art of inspiring and sustaining interest in others.

The entomologists of Canada have demanded a Canadian Entomological Society. This has now been recreated. It is for the members of this national Society, by whole-hearted financial support, by energetic efforts to recruit new adherents and above all by the provision of papers of high quality, to make the new Canadian Entomological Society a worthy successor to the first Entomological Society of Canada and the Entomological Society of Ontario.

THE EDITOR.

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